FACTORING WATER RESOURCES INTO ALGAL BIODIESEL PRODUCTION

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INTRODUCTION

The utilization of algae lipid has seen as one potential pathway to elevate national biofuel production. However, concerns have been raised in the impacts of algae refinery on local water resource due to the uncertainties in water consumption associated with evaporation and processing. Previous studies focuses on integrating algae refinery with the municipal wastewater (MWW) treatment plants for reducing nutrient costs. However, alternative water resource remains an essential issue in a sustainable algal oil production. Therefore, it is critical to fully evaluate the water footprint of algal biodiesel by taking local water availability into account. In this study, we examine water footprints of algal biodiesel in the southern 17 states in the U.S. and project biodiesel production potential based on available fresh water appropriation and MWW availability in addition to land resources. The blue and green water of the algal biodiesel, which account for make-up water and precipitation inputs respectively, are quantified from the algae growing, harvesting, to the refinery conversion stages. The result can provide detailed insights in supporting algal biodiesel development by taking long-term water sustainability into account.

METHODOLOGY

The algae growth potential is first determine giving the county-level environmental characteristics including climate and land resources (*1*). Additional technical assumptions are taken into account to the lipid-diesel conversion process (*2-4*). Evaporation model (*5*) and local water availability (*6-8*) are then coupled with the algae growth model for estimating sustainable capacity of the algal biofuel production. We define the available fresh water as the remained portion after deducting actual evapotranspiration and existing water consumption from precipitation. The production matrix of giving solely the land limitation as the base case is first establsihed. The biodiesel production scenarios associated with different water constraints are then compared to the base case.

RESULTS

The county-level blue water ranks from 23 to 4225 liter water per liter biodiesel (L/L), whereas green water ranks from 51 to 896 L/L under the base-case setting. This corresponds to an annual biodiesel production of 153 billion liters with occupying 155,800 km^2 of land and reusing 1,717 billion liters of MWW disregarding local fresh water supply capacity. However, the biodiesel production can experience 52% of reduction once the local fresh water is capped and fully consumed. With the decrease of consuming available water, the biodiesel production is decreased nonlinearly. The MWW can displace very minimal algal biodiesel blue water with an average of 1.5%, except Alabama where 17% of blue water can be displaced by MWW. Only ~1 billion liters of biodiesel can be produced if using MWW as the only water supply owing to the temporal and spatial constraints. Even without infrastructural limitation, the MWW can only support 5 billion liters of algal biodiesel production per year.

The modeling framework and its results provide a clear picture of algal biodiesel production by taking water resources into account. Our study also elucidates the importance of incorporating geographical and temporal challenges in projecting the potential production of algal biodiesel and the selection of refinery sites.

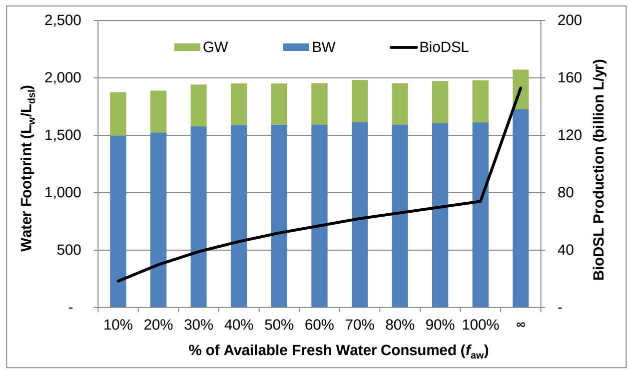

Figure 1: Change of the algal biodiesel production water footprint (GW=green water; BW=blue water) under different fresh water supply scenarios.

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